

Biology and distribution of the declining moth *Ethmia pyrausta* (Pallas, 1771), with description of the larva (Gelechioidea, Depressariidae, Ethmiinae)

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Abstract. Records of *Ethmia pyrausta* (Pallas, 1771) from the Baltic countries, the British Isles and Fennoscandia are listed. All known aspects of habitat requirements, larval biology and adult behaviour, mostly based on our own observations in the field, are described. Instructions for conservation and habitat management are presented. The larva is described and illustrated in detail.

Introduction, material and methods

Ethmia pyrausta (Pallas, 1771) (Figs 1, 2) is one of the rarities in the European fauna of the sub-family Ethmiinae. The species occurs sporadically in the hemiboreal zone in western and central parts of the Palaearctic region. Most of the records are old and the species is considered to be declining at least in its European distribution range. Although the larval host plant(s) and the flight period of the adult are known, there are very scarce data available on the behaviour of larvae and adults, as well as on the preferred habitats of the species.

During 2002–2006, the present occurrence and status of the populations of all protected Lepidoptera species was evaluated on the Åland Islands in the SW Finnish archipelago by Faunatica Oy (Nupponen et al. 2007). One of the fifteen focal species was *E. pyrausta*, which was known to have occurred on the islands, but no confirmed records of the species existed since the 1950s. One abundant population was discovered in 2005 by Kari Nupponen in the central part of the main island, where there were two studies of the larval behaviour (in July 2005 and 2006; Figs 3, 4). The species was also recorded close to the southern coast of Åland, where a single male was observed in early June, 2006, by Erkki and Leena Laasonen. Ene and Urmass Jürivete discovered another abundant population of *E. pyrausta* from SE Estonia in 2007, and adult behaviour was studied there in May 2008.

The description of the larva (below, Figs 5–10) is based on two caterpillars from Finström, Åland Island (25.vii.2006, see Table 1). The larvae were preserved in ethanol in the field, and later studied by Matti Ahola. The hypopharyngeal complex, mandibles and labrum of the larval head

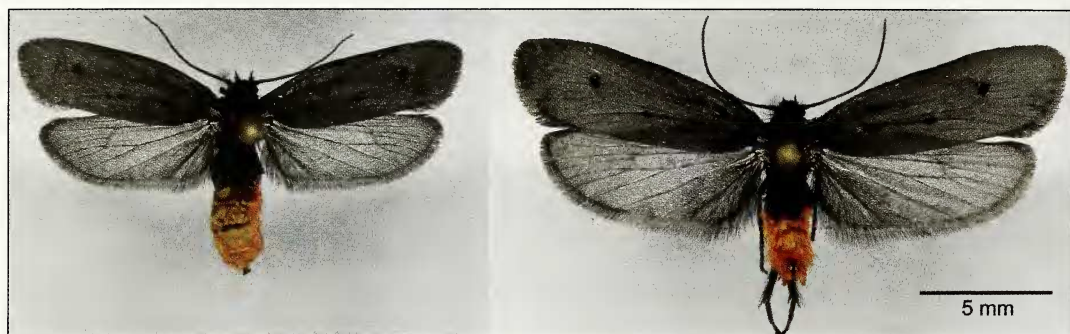


Figure 1. Adults of *Ethmia pyrausta* (Pallas, 1771) (Finland, Al: Finström, e.l., larvae found 25.vii.2006 on *Thalictrum flavum*).

were dissected and mounted on slide. The chaetotaxy was studied from larvae in alcohol, and the living larva (Fig. 4) was photographed to show the habitus. Naming of the setae follows Hinton (1946) as interpreted by Ahola and Silvonen (2005).

Distribution

Ethmia pyrausta was described from the Samara region, the eastern part of European Russia, in the 18th century (Sattler 1967). There are two recent records of *E. pyrausta* from the steppes of the Ural Mountains (Nupponen in press) and another one from Uljanovsk district (W. Mey, pers. comm.), but apparently the species is very rare in the Volgo–Ural region. In Russia, the species is known to occur widely but sporadically in the hemiboreal zone, from Karelia in the west to the Baikal region in the east (Sinev 2008). It is also known from Mongolia (Ulan-Bator) and China (Kuldzha, Xinjiang) (Dubatolov et al. 1997, Dubatolov 2014). In western Europe, *E. pyrausta* occurs only in Scotland, Sweden, Finland and the Baltic countries.

In Scotland, *E. pyrausta* is restricted to the Highlands. It was known by a single specimen discovered in May 1853 on the banks of the River Shin, until two specimens were unexpectedly found in 1996 in the Cairngorms (about 1000 m a.s.l.) (Anonymous 2014; Kimber 2014). Subsequently several further specimens were found, one at Loch Vrotachan on the NNW end of Cairnwell, Aberdeenshire (810 m a.s.l., 28.v.2001), one at the River Averon close to Loch Morie, East Ross-shire (8.v.2008), one on the slopes of Ben Griam Mor in 2012, and 15 specimens in Croick Estate (24. iv.–31.v.2014) (Anonymous 2014).

In Sweden, *E. pyrausta* has declined severely. It has been recorded in eight provinces in the central part of the country (Gustafsson 2012). However, only from two provinces, viz. Uppland and Dalarna, are there rather recent records. Here the moth occurs along the River Dalälven, but no records are known from the most recent years (Nils Ryrholm, pers. comm.).

In Finland, *E. pyrausta* occurs with certainty only on the Åland Islands, where it is apparently declining due to habitat loss. Most records are from the 1940s and 1950s, and many populations have vanished since (Nupponen et al. 2007). Since the 1950s, there are only confirmed records from two localities. Additionally, there is a single record of the species from the southern coast of the Finnish mainland (Helsinki, 1 larva, 1946; Hyönteistietokanta 2014), thus its occurrence in southern Finland cannot be excluded.



Figure 2. Female of *Ethmia pyrausta* in resting posture (Finland, Al: Finström, e.l., larva found 25.vii.2006).



Figure 3. Moist meadow in Finström, central Åland Islands. Habitat of *Ethmia pyrausta* (photo: K. Nupponen).



Figure 4. Larva of *Ethmia pyrausta* on *Thalictrum flavum* (Finland, Al: Finström, 19.vii.2005) (photo: K. Nupponen).

In the Baltic countries, the species occurs sporadically in Latvia (Šulcs and Šulcs 1978, Savenkov and Šulcs 2010) and Estonia (Nolcken 1871, Petersen 1924, Jürivete and Ōunap 2008). There is also one locality for the species in northern Lithuania close to the Latvian border (Povilas Ivinskis, pers. comm.). The Finnish and Baltic records of *E. pyrausta* known to us are listed in Table 1.

Description of the larva

Larvae of the genus *Ethmia* have a chaetotaxy generally typical of Lepidoptera, with one exception: D2 setae of abdominal segment 9 are laterad of D1 unlike other Gelechioidea, but similar

Table 1. Records of *Ethmia pyrausta* (Pallas, 1771) from Finland and the Baltic countries.

Locality	Date	Specimens	Observer(s)	Notes
FINLAND				
Al: Geta	1920s	5	J. Montell	
Al: Jomala, Gottby utång	9.v.1943	1 male, 1 female in copula	M. Donning	
Al: Finström	1945	Ca. 30 larvae, reared 10 adults	A. Nordman	
N: Helsinki	viii.1946	1 larva	J. Grönvall	
Al: Eckerö, Öra 671:309	1947 & 1948	Several larvae	A. Nordman & J. Waselius	
Al: Eckerö, Skag 671:309	1948	Larvae, emerged 6 adults	A. Nordman	
Al: Geta	1952	Several larvae, emerged 6 adults	M. von Schantz	
Al: Eckerö, Skag 671:309	1952	Larvae, emerged >30 adults	H. Bruun	
Al: Lemland	1956	Larvae, emerged 9 adults	O. Nylund	
Al: Finström, Norrö	1950s	Larvae	H. Bruun	
Al: Hammarland	1950s	?	H. Bruun, unpubl.	Not confirmed
Al: Eckerö, Skag 671:309	1970s	1 larva	J. Kangas	Doubtful record, identification not confirmed
Al: Lemland	8.vii.1984	1 larva	E. Peltonen	Doubtful record, identification not confirmed
Al: Finström 670:310	19.vii.2005	28 larvae	K. Nupponen/ Faunatica Oy	
Al: Lemland, Flakaviken 667:312	8.vi.2006	1 male	E.M. & L. Laasonen/ Faunatica Oy	
Al: Finström 670:310	25.vii.2006	150 larvae	K. Nupponen/ Faunatica Oy	
ESTONIA				
E Saaremaa, Pihlta	1859–1867	Several males, 1 female	Nolcken	Dates of records: 28.iv.–10.v.1865 several, 10.–17.v.1866, 29.v.–6.vi.1867 about 5 adults
E Saaremaa, Pihlta	1866–1867	Larvae	Nolcken	Half-grown larvae in late June, 1866
Tallinn, Habersti (near lake Harku)	30.v.1900	2 males	Petersen (1924)	
SE Estonia	After 1950	?	J. Luig, unpubl.	
Tallinn, Pääsküla	20.v.2003	1 male	A. Lindt	By light trap
SE Estonia, river Piusa, Veski	v.2007	1 male	R. Haverinen	By light trap
SE Estonia, river Piusa, Veski	24.vi.2007	>20 larvae	E. & U. Jürivete	
SE Estonia, river Piusa, Veski	12.v.2008	>20 males	E. & U. Jürivete	
SE Estonia, river Piusa, Veski	v.2008	1 male	E. Öunap	
SE Estonia, river Piusa, Veski	17.v.2014	1 male	E. & U. Jürivete	
LATVIA				
Salaspils	v, <1889	1	Teich	
Salaspils	viii, <1889	Larvae	Teich	

Locality	Date	Specimens	Observer(s)	Notes
Salaspils	16.v.1976	13	A. & I. Šulcs	
Salaspils	21.v.1977	1	A. & I. Šulcs	
Salaspils	22.v.1978	6	A. & I. Šulcs	
Krievupe (Riga district)	5.vi.1987	1 male	A. Titov	
W-Latvia, Ķemeri (Apšupe)	1.vi.1993	1 male	N. Savenkov	
W Latvia, Ķemeri (Kūdra)	23.v.1995	1 male	A. Titov	
W Latvia, Ķemeri (Kūdra)	10.v.1998	1 male	A. Titov	
SE Latvia, Šķaune	v.2005	1 male	I. Šulcs	By light
SE Latvia, Šķaune	6.vii.2006	Several larvae	N. Savenkov	
LITHUANIA				
N Lithuania, Dukstyna reserve (near Ukmerge town)	1970s	Larvae	P. Ivinskis	

to Cryptolechiinae (Kaila 2004, Heikkilä *et al.* 2014). Setae A1–3 and L1 on head form a nearly straight line, and secondary setae are present on abdominal SV groups, including both the prolegs and the 9th abdominal segment. *E. pyrausta* differs from other ethmiine species by having secondaries only on 9th abdominal segment.

Head morphology: Head semiprognathous, rather rounded, surface smooth but not shining, frontoclypeus slightly longer than epicranial suture, adfrontal suture joined to epicranial suture before vertical notch. Six stemmata present on each side, nearly equal in size but stemma 2 slightly smaller, stemmata 5 and 6 in line with caudal margin of antennal socket. Spinneret tubular, tapering distad and proximad, about three times as long as wide. Labial palpi slender, segment Lps1 two times longer than wide, seta Lp1 about twice as long as segment Lps2, seta Lp2 as long as Lps1 (Fig. 5). Stipular setae shorter than Lp2 of labial palpi, position on chitinised part of prementum. Hypopharynx largely bare, median and lateral parts of posterior region covered with tiny spines (Fig. 6). Laciniogalea of maxillae with stout sensilla, Ss2 thicker than Ss1 on galeal lobe and St1 thinner than St2–3. Maxillary palpi with stout third segment, longer than second one (Fig. 7). Cutting margin of mandible with very tiny ventral tooth and with straight and smooth edge of second dorsal tooth. Other teeth unspecialized. Three inner ridges present on inner surface of mandible. Labrum with low and rather large notch, seta LR1 situated on level with LR2, setae LR5 and LR6 separately on line with seta LR4 (Fig. 8).

Chaetotaxy: Position of P1 setae on level with AF2 on head, distance P1–P1 shorter than P2–P2, setae A1, A2 and A3 situated straight on line. Setae D1 and D2 of prothoracic shield close to each other, seta SD2 also on shield but SD1 not. Three L setae and two SV setae present on prothorax; L1 distinctly ventrad of L2 and L3. Thoracic segments Th2–3 have D1 and D2 setae close to each other and SD1 close to SD2, all on same pinaculum, seta SV1 on large pinaculum and microseta MD1 also on pinaculum. Three L setae and two MSD microsetae without pinacula, one additional sclerotized plate present behind D setae (Fig. 9). Abdomen has large pinacula separately around D1 and D2 setae on segments Ab1–7, position of seta D1 cephalad from D2 on segment Ab9, setae SD1 and SD2 on same pinaculum on segments Ab1–8 and larger pinacula around setae

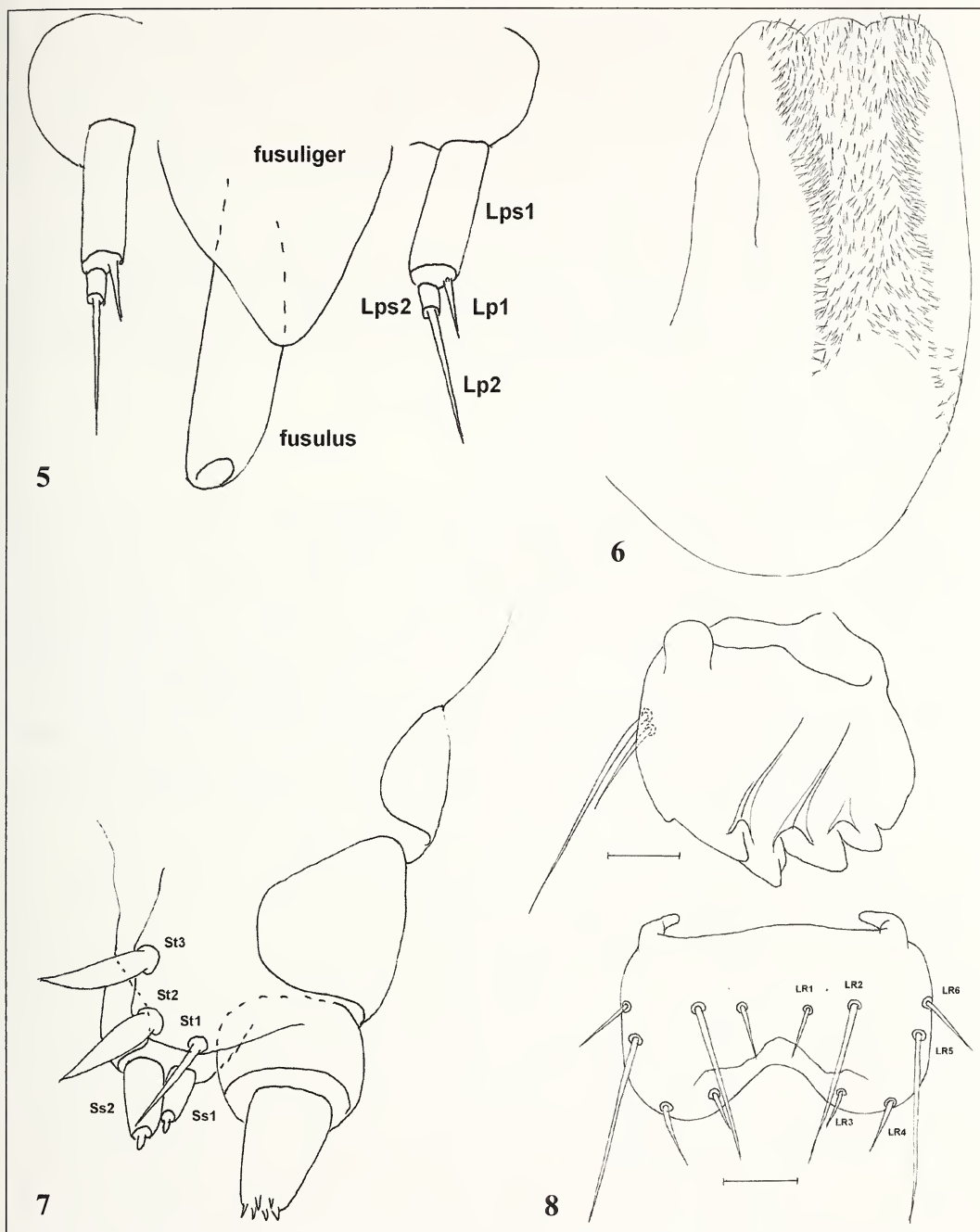


Figure 5-8. *Ethmia pyrausta*: **5.** Morphology of mouthparts, spinneret and labial palpi in dorsal view; **6.** Hypopharynx from dorsal view; **7.** Maxillae with maxillary palpi and sensilla of galeal and lacinial area; **8.** Labrum and left mandible (scale bar = 0.1 mm).

L3 and V1 on segments Ab1–7. Setae L1 and L2 situated close to each other on segments Ab1–9, seta L3 present also on segment Ab9. Small pinaculum around seta L2 on segments Ab1–5. Three SV setae present on segments Ab1–6, two SV setae on segments Ab7–8 and one long SV and numerous secondary setae on segment Ab9 (Fig. 10). Anal shield with D1 setae on level with SD2, setal distance D2–D2 longer than D2–SD1 and small spines present between setae D2–D2 (Fig. 9). Seta D2 long on abdominal segments Ab1–Ab9 but seta SD1 longer on anal shield. Crochets of abdominal prolegs biordinal in mesal penellipse.

Larval habitus: Head smooth with pale green postclypeus, adfrons, dorsal part of frons and narrow stripe from adfrons behind stemmata; head otherwise black. Sides of prothoracic shield and pinacula of body black. Broad orange flecks in place of middorsal and spiracular lines, dorsal zone between middorsal line and D2 setae dark greenish especially on thorax, but larva otherwise dull white.

Notes on the biology

The habitats of *E. pyrausta* are open and sunny moist meadows, often located at the shore or riverside (Fig. 3). Ovipositing females apparently prefer microhabitat with rather sparse, lower vegetation and warmer microclimate than in the adjacent grassy areas. Usually such a habitat exists as a narrow belt between forest and dense stands of *Salix* or *Phragmites*. The species has never been found in forests, even in localities where the host plant is abundant in semi-shadowed open patches within the forest. A common feature for localities of *E. pyrausta* is that they are open to the southeast or east, and sunshine reaches the spots in the early morning.

The larva is oligophagous on *Thalictrum* species (Ranunculaceae). In Finland, the only recorded host plant is *Thalictrum flavum* L. (Fig. 4), probably due to the fact that other species of *Thalictrum* do not occur or are very rare in the region where *E. pyrausta* occurs. In Estonia, larvae have also been found on *Thalictrum aquilegiifolium* L. (Nolcken 1871, Petersen 1924) and *T. lucidum* L. (E. & U. Jürivete, pers. comm.). In an average season, larvae are of detectable size from late June and they pupate in the first half of August. They feed on flower-buds, flowers and seeds. Full-grown larvae feed also on leaves, but only when all seeds are eaten up. Larvae live singly and freely on the host plant, although sometimes two to three larvae have been observed on one plant. Contrary to what is stated in the literature (e.g. Emmet 1979) we did not detect any webs made by larvae on the plants. The presence of larvae can be presumed from the evidence of partly eaten seeds. However, larvae of some other Lepidoptera feed on seeds of *Thalictrum* too, and sometimes they occur sympatrically with *E. pyrausta*, e.g., the geometrid *Gagitodes sagittatus* (Fabricius, 1787). Therefore, the occurrence of *E. pyrausta* should always be confirmed by direct observation of a larva, not just by feeding damage.

Larval behaviour was studied three times: twice on the Åland Islands (19.vii.2005 and 25.vii.2006) and once in the south-eastern Estonia (24.vi.2007). The larva is predominantly nocturnal. On Åland, three larvae were observed on 19.vii.2005 at 6 p.m. and 25 larvae from 11:30 p.m. to 00:15 a.m. (local summer time, i.e. +3 h GMT). On 25.vii.2006 in the same locality, there were no signs of larvae earlier in the day (3–4 p.m.), while about 150 almost full-grown larvae were observed at night from 11:30 p.m. to 1 a.m. In SE Estonia, altogether more than 20 larvae of various ages were observed on 24.vi.2007 at dusk. Larvae become active at dusk, and climb onto the host plant to eat seeds. They eat during a rather brief period (maximally half an hour), and then return to hide in the litter. The larvae move rapidly and drop onto the ground very easily when disturbed. Later at night they are less

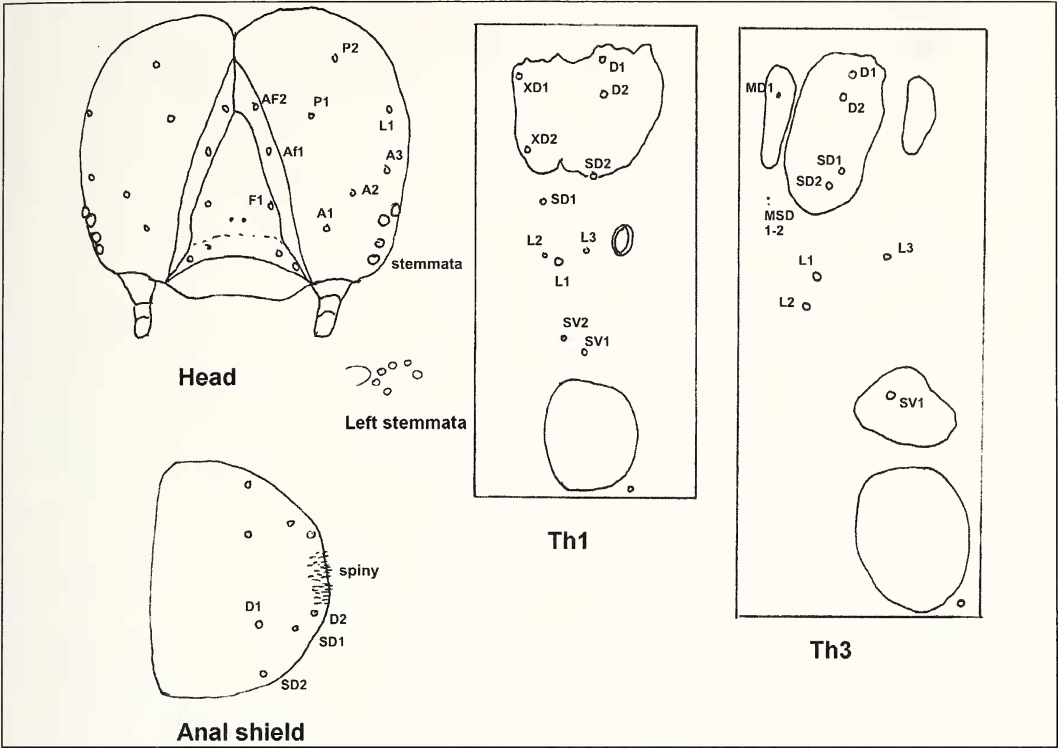


Figure 9. *Ethmia pyrausta*: Chaetotaxy of head, thorax and anal shield, and left stemmatal ring.

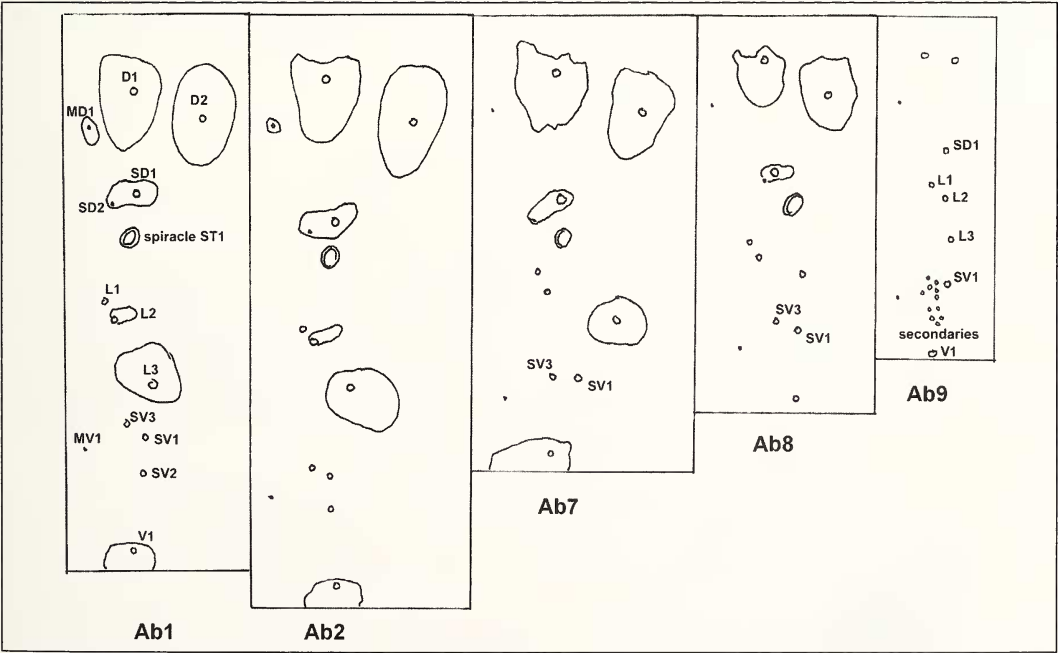


Figure 10. *Ethmia pyrausta*: Chaetotaxy of abdomen.

active, possibly due to decreasing temperature and especially fog that often forms in such habitats at night. During the second half of the night and daylight, larvae are mainly hiding in the soil, and only occasionally visit their host plants to feed. Nolcken (1871) detected larvae on their host during daylight, but he did not present further notes on the time of the records. Pupation takes place in a dirty white or pale yellow cocoon in detritus on the ground. We did not rear any parasitoids from the larvae. It is also possible that the behaviour of parasitized larvae changes and, thus, they cannot be observed with the same methods.

The main flight period is in May with a peak about one to two weeks after budburst of birch. In years with a late season and close to the seashore, the flight period starts later and extends even to mid-June. Nolcken (1871) recorded adults in the period 28 April to 6 June (in 1865–1867), but the annual flight period did not last more than two weeks. The adult of *E. pyrausta* is predominantly diurnal. Occasionally, males fly at night too and come to light, usually on extremely warm nights. In south-eastern Estonia, the behaviour of adults was studied on 12.v.2008. The previous night was cold and the temperature decreased to +1°C in the second half of the night. In the morning, the sky was clear and sunshine heated the wet vegetation from early morning. The first *E. pyrausta* male was observed at 7:30 a.m., while the temperature was still low. Most males became active just after 8 a.m., and over 20 individuals were observed between 8 a.m. and 9 a.m. After that, flight virtually stopped. During the active flight period, males were flying rather slowly and close to the ground (height of flight about 1 m), probably searching for females. Šulcs and Šulcs (1978) recorded similar ‘swarming’ of *E. pyrausta* in early morning. Males appear to re-activate at the middle part of the day between 10 a.m. and 2 p.m., when the moths fly rapidly, straighter and higher (height of 2.5–3 m) than in the morning (Nolcken 1871; U. Jürivete unpublished; E. Öunap pers. comm.). It is difficult to observe rapidly flying dark moths, and because of that, the species is seldom recorded by chance. As far as we know, there are no records of an evening flight of *E. pyrausta*. Females do not seem to fly much, but prefer to sit among the vegetation and presumably attract males.

Conservation

Ethmia pyrausta shows a highly sporadic distribution throughout its known range. It has apparently declined at least in the western parts of the range. For example, the occupancy of *E. pyrausta* was systematically studied in 34 patches of *T. flavum* – including traceable previous findings – throughout the Åland Islands in 2005 and 2006, but it was present in only one open and sunny patch (Fig. 3) (Nupponen *et al.* 2007). On the other hand, the population in that patch was relatively large. Based especially on the negative trends in various habitat characteristics, e.g. decreasing amount and quality and high degree of fragmentation, the species has been rated as threatened both in Finland (Kaitila *et al.* 2010; CR: criteria B1ab(iii)c(iv)+2ab(iii)c(iv)) and Sweden (Bengtsson *et al.* 2010; EN: criteria B2ab(i,ii,iii,iv,v)).

Ethmia pyrausta requires host plants that are growing in full sunshine. Therefore, the main reason for the decline, at least in Finland and Sweden, is overgrowing of moist meadows after cessation of grazing. All management activities should be performed late in the season, i.e. in August at the earliest. This should ensure that *E. pyrausta* larvae have time to pupate before management starts. Further, *Thalictrum* is highly vulnerable to grazing (Anonymous 2014; own observations) and only late-season grazing or mowing can be recommended. Unfortunately, such late-season management has almost ended in Sweden and Finland, even though plenty of herbivorous insect species are highly

dependent on it (Dahlström et al. 2008). In management, the first thing to take care of is to create and maintain open sunny patches of moist meadow with plenty of host plants. Habitats occupied by *E. pyrausta* are regularly dominated by *Filipendula ulmaria* (Rosaceae), and usually the main aim is to reduce its abundance by mowing. If meadows are mown, only areas without *Thalictrum* should be cut. However, in meadows that are grazed earlier than recommended, *F. ulmaria* protects plants growing among it against grazing, so reasonable amounts of *F. ulmaria* in microhabitats with *Thalictrum* are beneficial in those cases (Anonymous 2014).

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